A New Technique for Analyzing The Optical Spectrum of Stamp Inks

U.S. 1861 Case Study

Edward (Ted) Liston PhD, FRPSL

11/18/15

WHAT IS A SPECTROMETER?

A Spectrometer is an optical Instrument that measures the reflectance of a sample that his placed at a focal point in the instrument. In our case, we have use of spectrometers made by the Foster + Freeman Co., Model "Visual Spectral Comparator 6000". This name will be shortened to VSC in this paper.

In our work, a stamp is placed inside the instrument and light is shined on it. The amount of reflected light is then measured at 600 different Wavelengths (colors) in the visible to near infrared range. Those reflectivity data are then plotted to show the amount of light reflected at each color. This plot is called the "Spectrum."

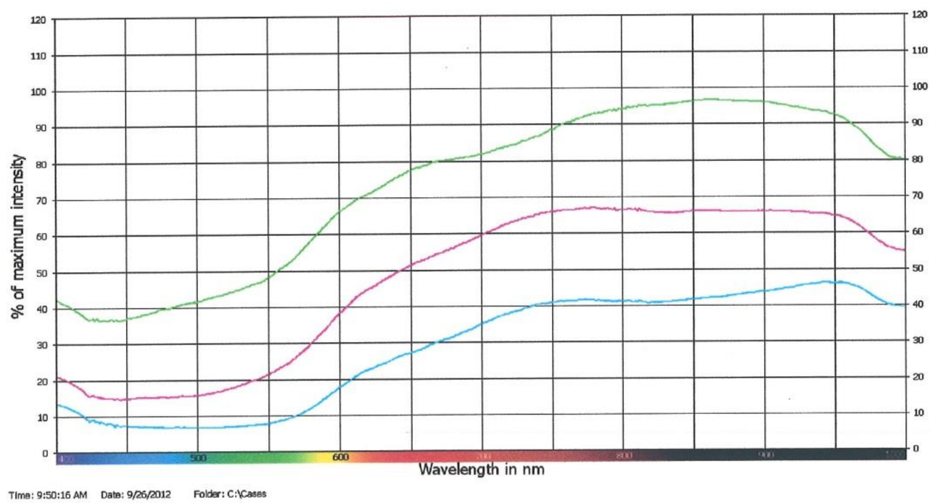
The VSC also produces a table of the reflectance at each color. This table is the data that are used to calculate the "Average" and the "Difference" spectra.

WHAT IS A SPECTRUM?

Figure 3 shows 3 typical spectra as given by the VSC

The light green is for "Burnt Sienna"
The light red is for "yellow iron oxide"
The light is for "Red iron oxide"

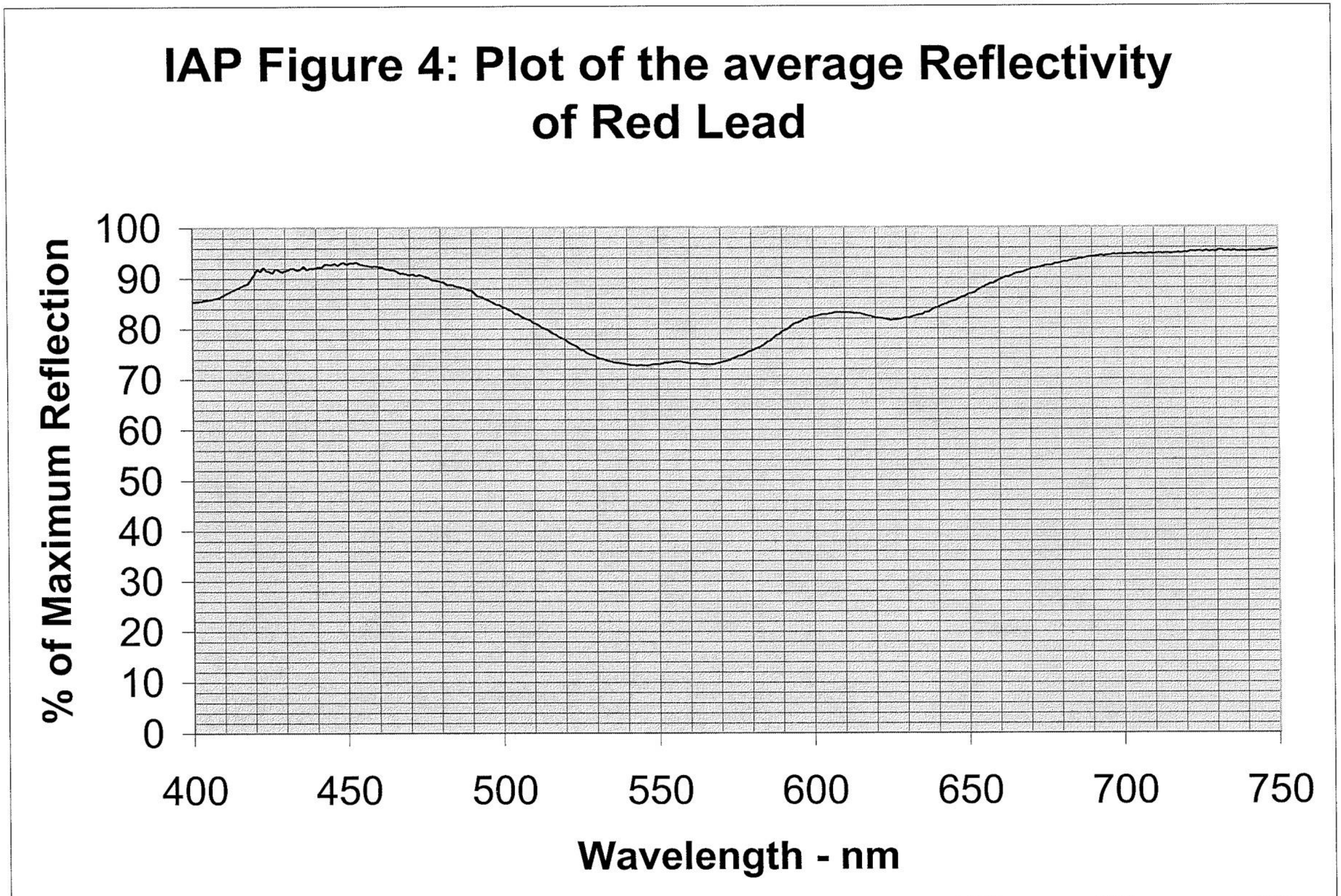
1	Ref	Light Mauve	11		
2	Ref	Dark Mauve	12		
3	Ref	Burnt Sienna	13		
4	Ref	Yellow Iron Oxide	14		
5	Ref	Red Iron Oxide	15		
6	Ref	Ult. Blue	16		
7	Ref	Senz Rose Mad	17		
8	Ref	Genuine Rose Madder	18		
9	Ref	WV P3	19		
10			20		



These plots show the measured reflectance at six hundred colors, from 400nm at the blue end to very deep red at the left end. The numbers at the bottom of the plot (in the "rainbow") are the "wavelength of the reflected light " which are the units that are used in this paper.

These plots demonstrate the major problem with the normal spectra. They are very nearly alike even though they are from very different color pigments. Also, they show very little "information," they are just lumpy lines.

The solution is to make "Differential" spectra.

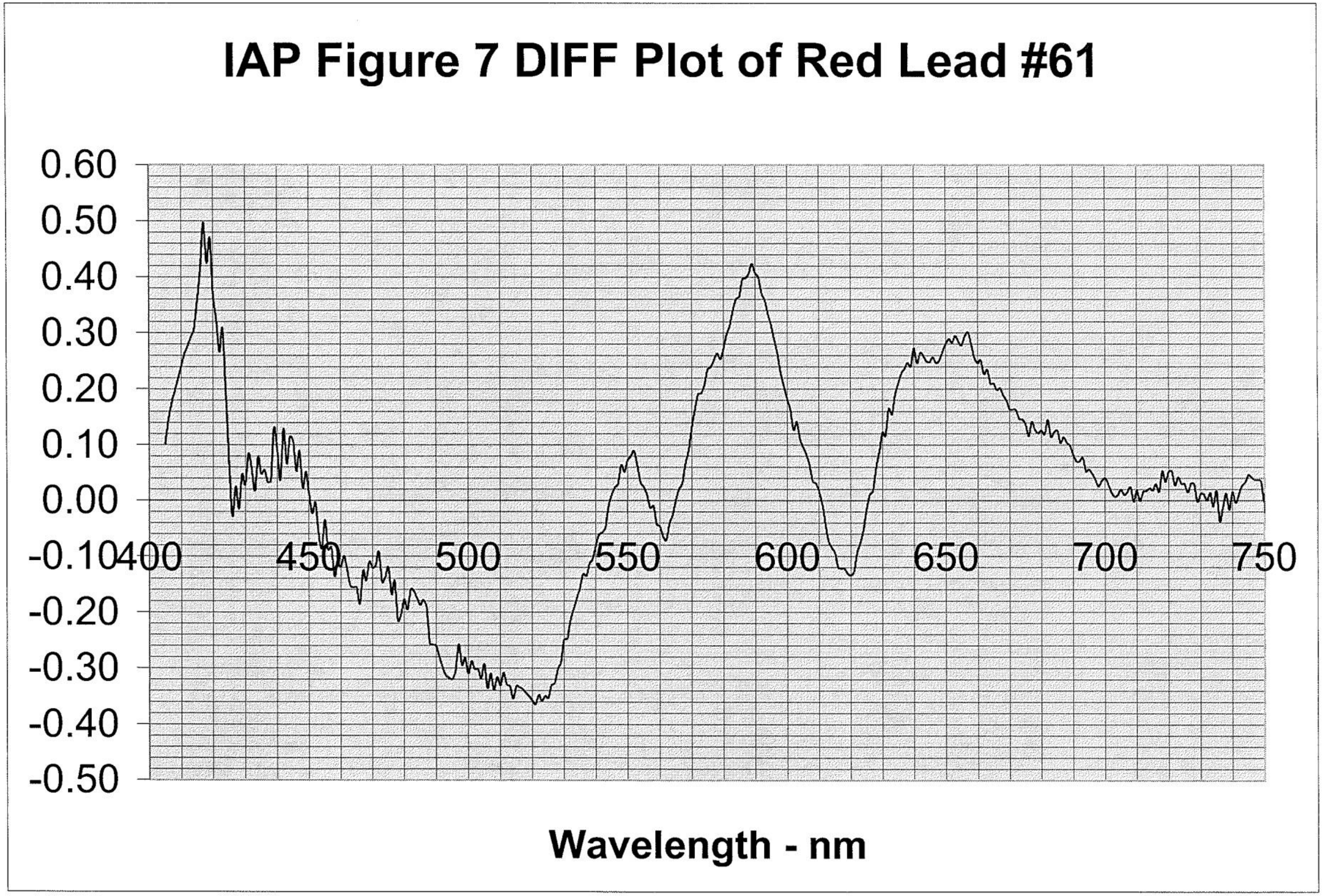

IAP Figure 4: Plot of the average Reflectivity of Red Lead
% of Maximum Reflection
100
90
80
70
60
50
40
30
20
10
0
400
450
500
550
600
650
700
750
Wavelength - nm

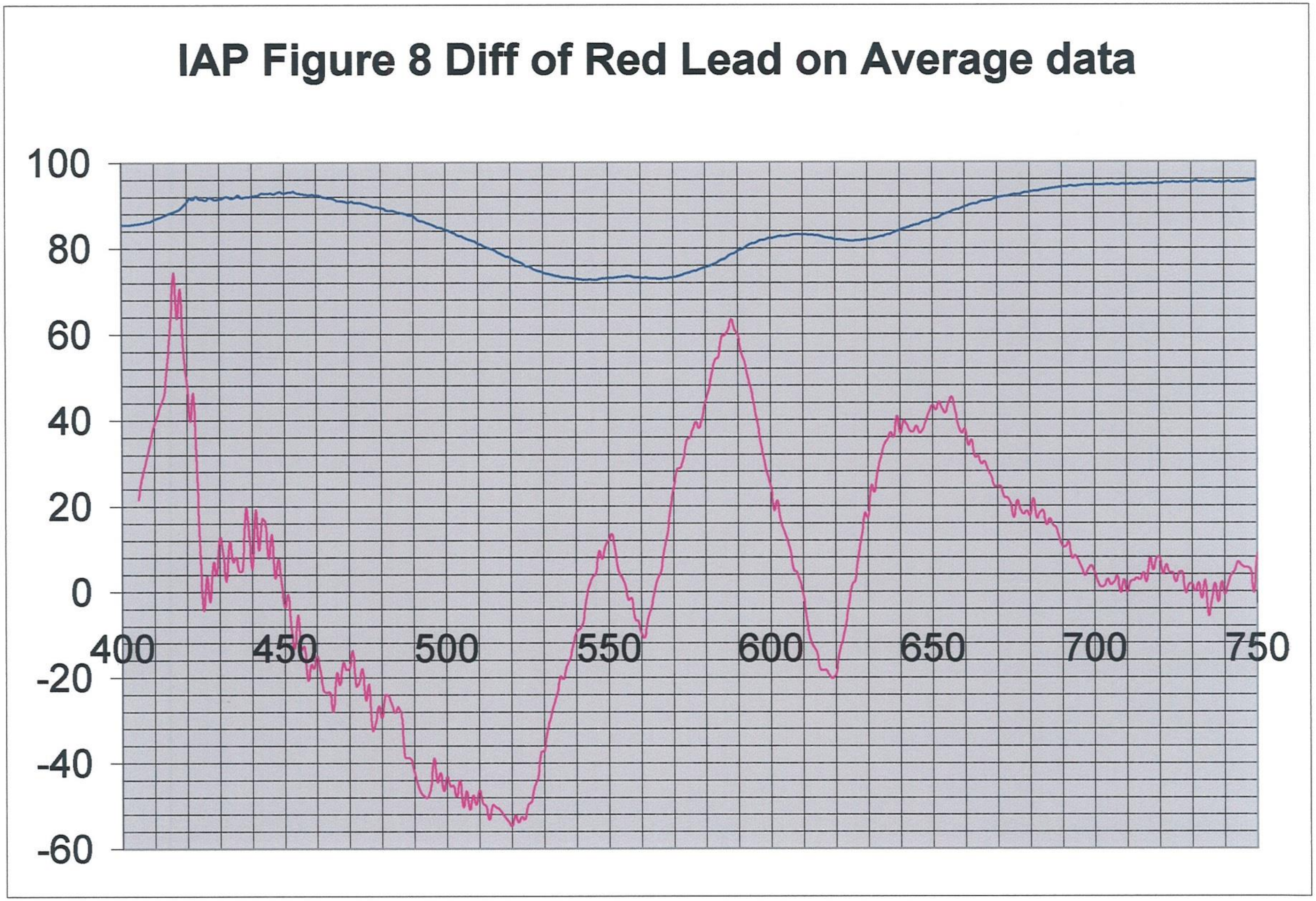
IAP Figure 5 Master Program for calculating the reflectivity of the Average data.

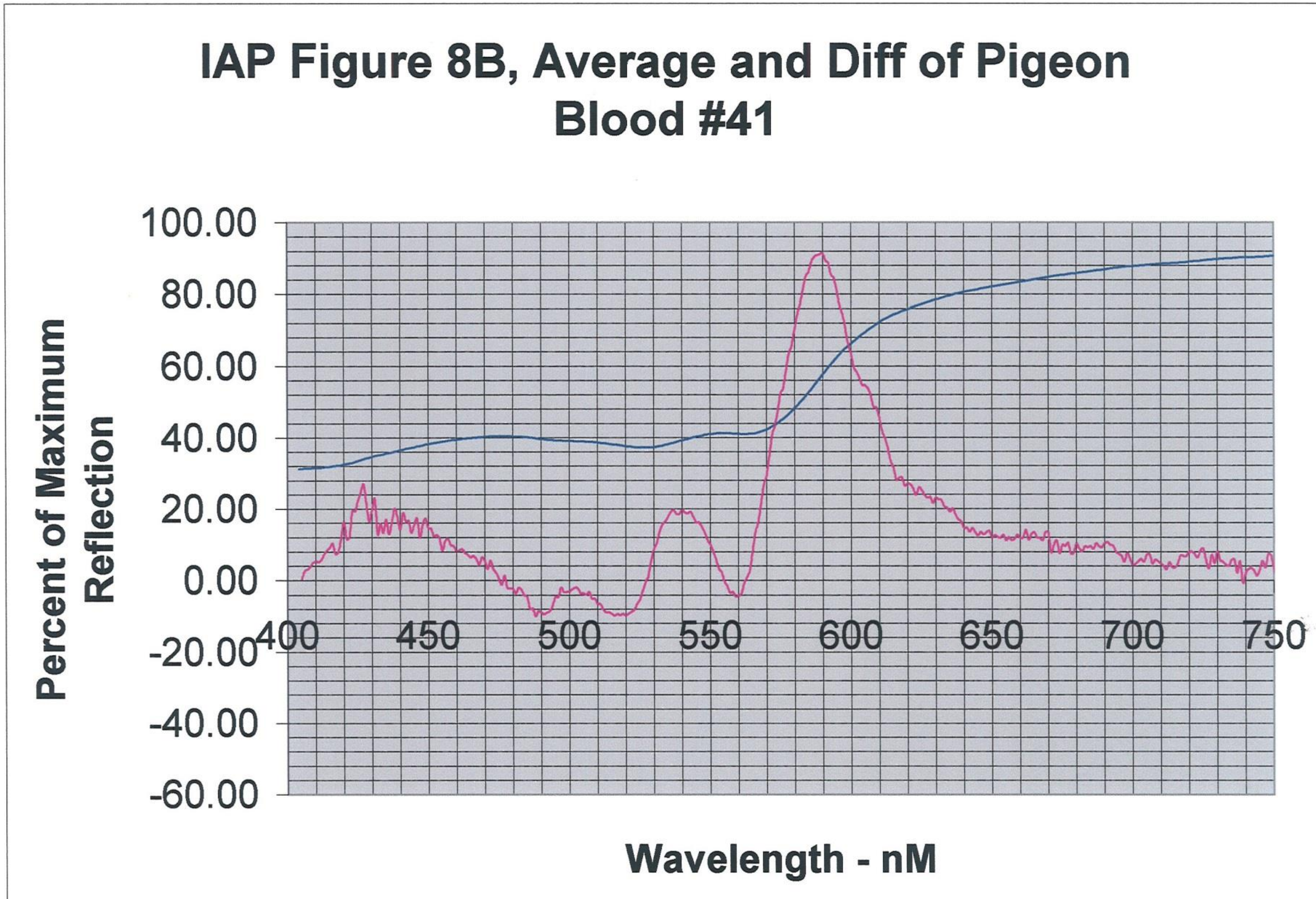
			Data from Smithsonian P. 58 stamp number							
wavelength			41.00	42	43	44	45	46	47	
	avg. reflect.	avg. reflect.	Reflectrivity							
400			31.37	30.71	20.66	22.21	13.51	14.29	19.6	17.33
401			31.24	30.71	20.58	22.21	13.45	14.3	19.62	17.36
402			31.24	30.71	20.57	22.21	13.57	14.45	19.74	17.43
403			31.22	30.71	20.63	22.21	13.87	14.58	19.91	17.52
404	31.29	31.28889	31.19	30.71	20.62	22.21	13.87	14.68	19.91	17.62
405	31.29	31.29222	31.25	30.73	20.76	22.21	14.07	14.91	20.12	17.84
406	31.32	31.32111	31.36	30.75	20.88	22.36	14.24	15.09	20.29	18.05
407	31.36	31.35556	31.38	30.75	20.93	22.46	14.31	15.19	20.39	18.18
408	31.40	31.39778	31.35	30.72	20.96	22.53	14.41	15.29	20.47	18.28
409	31.45	31.45222	31.40	30.74	21.06	22.66	14.58	15.44	20.65	18.44
410	31.51	31.51111	31.50	30.75	21.24	22.91	14.89	15.72	20.97	18.78
411	31.57	31.56667	31.55	30.76	21.34	23.06	15.09	15.91	21.19	18.99
412	31.63	31.63	31.60	30.75	21.45	23.23	15.31	16.14	21.42	19.24
413	31.71	31.71222	31.68	30.77	21.59	23.41	15.55	16.38	21.67	19.49
414	31.80	31.80444	31.78	30.8	21.72	23.59	15.79	16.62	21.92	19.75
415	31.91	31.90556	31.86	30.82	21.85	23.77	16.02	16.86	22.16	19.99
416	32.02	32.02	31.95	30.85	21.98	23.96	16.26	17.11	22.42	20.25
417	32.10	32.10333	32.09	30.91	22.15	24.18	16.55	17.4	22.71	20.56
418	32.19	32.19222	32.23	30.97	22.32	24.4	16.84	17.68	23	20.86
419	32.32	32.32111	32.41	31.04	22.74	24.95	17.54	18.29	23.68	21.57
420	32.50	32.50222	32.58	31.1	23.16	25.5	18.24	18.9	24.35	22.28
421	32.63	32.63111	32.35	30.98	22.84	24.97	17.71	18.36	24.34	21.81
422	32.77	32.76667	32.48	30.51	22.98	25.36	18.18	19.09	24.34	22.51
423	32.98	32.98333	32.94	31.35	23.47	25.64	18.48	19.27	24.87	22.67
424	33.20	33.19889	33.49	31.29	23.58	25.6	18.67	19.39	24.92	22.8
425	33.45	33.44778	33.11	31.28	23.19	25.58	18.28	19.31	24.62	22.35
426	33.72	33.72333	33.31	31.3	23.43	25.74	18.66	19.4	25	22.88
427	34.02	34.02333	34.18	32.12	24.35	26.28	19.58	20.47	25.69	23.71
428	34.26	34.26111	34.35	32.01	24.2	26.46	19.52	20.1	25.68	23.75
429	34.44	34.44333	34.82	32.14	24.8	26.8	20.02	20.86	26.61	24.34
430	34.66	34.66222	34.83	32.31	24.29	26.64	19.82	20.86	25.93	24.05
431	34.92	34.91667	35.18	32.22	24.58	26.85	20.17	21.13	26.29	24.48

IAP Figure 6 Master Program for calculating the DIFFerent P. 58 stamp number

wavelength	difference	difference	9pt avg.	reflectivity	slope difference calculation
				41.00	
400				31.37	
401	0.00	0.00		31.24	
402	0.00	0.00		31.24	
403	0.00	0.00		31.22	
404	0.00	0.00	31.29	31.19	
405	0.00	0.00	31.29	31.25	31.29 - 31.29 = 0.00
406	0.03	0.03	31.32	31.36	31.32 - 31.29 = 0.03
407	0.04	0.04	31.36	31.38	31.36 - 31.32 = 0.04
408	0.04	0.04	31.40	31.35	31.40 - 31.36 = 0.04
409	0.05	0.05	31.45	31.40	31.45 - 31.40 = 0.05
410	0.06	0.06	31.51	31.50	31.51 - 31.45 = 0.06
411	0.06	0.06	31.57	31.55	31.57 - 31.51 = 0.06
412	0.06	0.06	31.63	31.60	31.63 - 31.57 = 0.06
413	0.08	0.08	31.71	31.68	31.71 - 31.63 = 0.08
414	0.09	0.09	31.80	31.78	31.80 - 31.71 = 0.09
415	0.10	0.10	31.91	31.86	31.91 - 31.80 = 0.10
416	0.11	0.11	32.02	31.95	
417	0.08	0.08	32.10	32.09	
418	0.09	0.09	32.19	32.23	
419	0.13	0.13	32.32	32.41	
420	0.18	0.18	32.50	32.58	
421	0.13	0.13	32.63	32.35	
422	0.14	0.14	32.77	32.48	
423	0.22	0.22	32.98	32.94	
424	0.22	0.22	33.20	33.49	
425	0.25	0.25	33.45	33.11	
426	0.28	0.28	33.72	33.31	
427	0.30	0.30	34.02	34.18	
428	0.24	0.24	34.26	34.35	
429	0.18	0.18	34.44	34.82	
430	0.22	0.22	34.66	34.83	
431	0.25	0.25	34.92	35.18	


IAP Figure 7 DIFF Plot of Red Lead #61
0.60
0.50
0.40
0.30
0.20
0.10
0.00
-0.10
-0.20
-0.30
-0.40
-0.50
400
450
500
550
600
650
700
750
Wavelength - nm


IAP Figure 8 Diff of Red Lead on Average data
100
80
60
40
20
0
-20
-40
-60
400
450
500
550
600
650
700
750


IAP Figure 8B, Average and Diff of Pigeon Blood #41
100.00
80.00
60.00
40.00
20.00
0.00
-20.00
-40.00
-60.00
400
450
500
550
600
650
700
750
Percent of Maximum Reflection
Wavelength - nM



ROSE



ROSE PINK

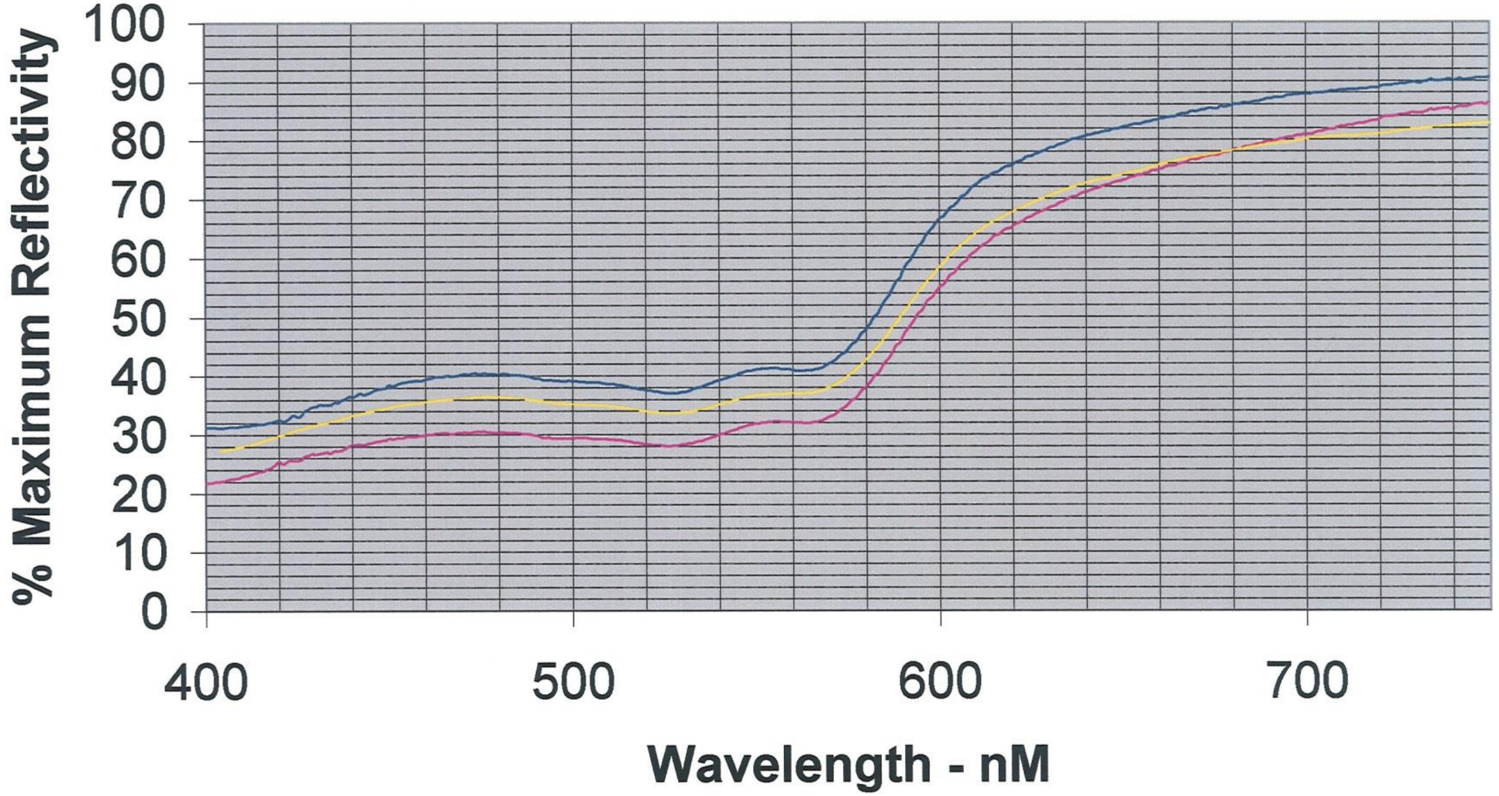


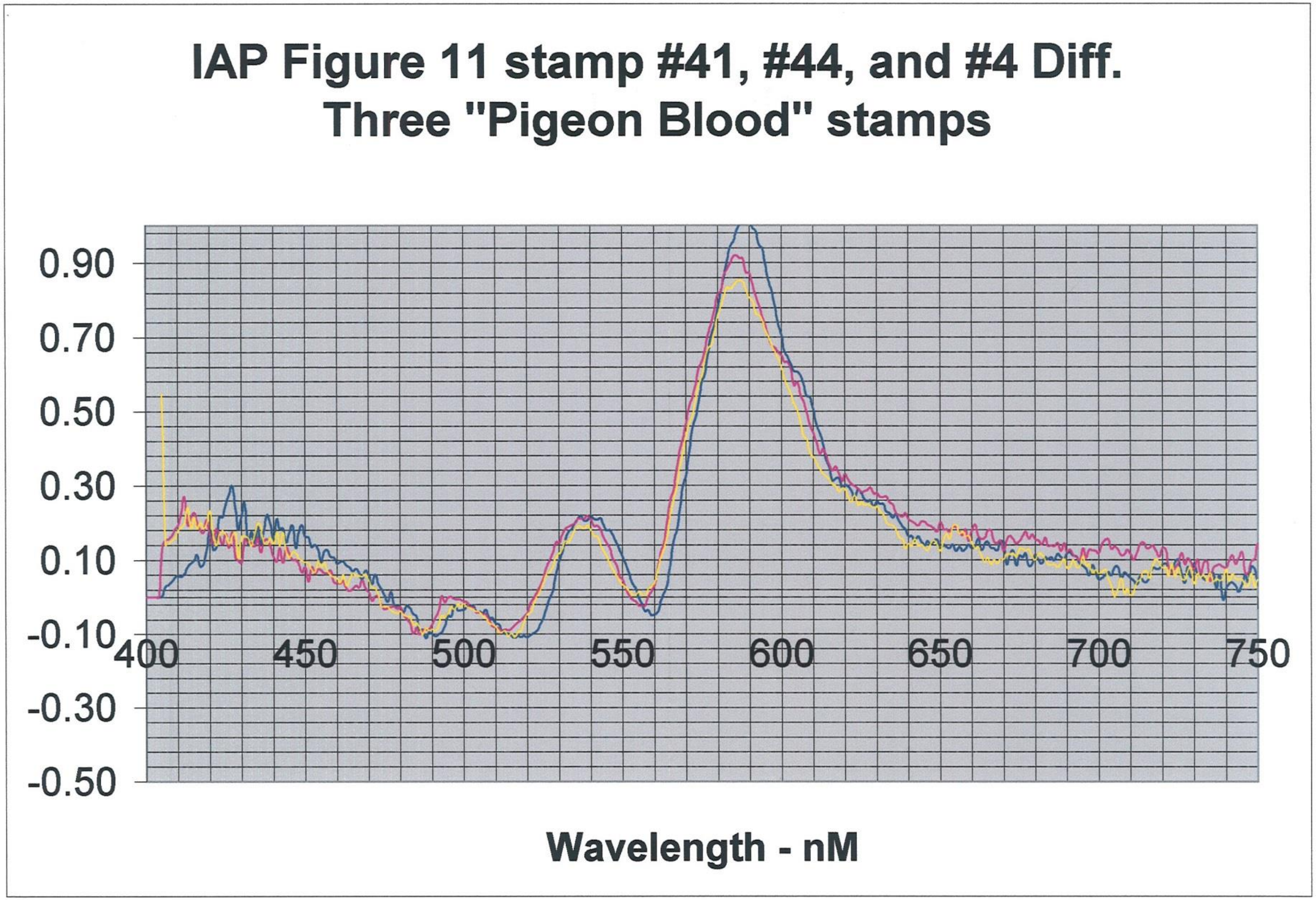
PINK

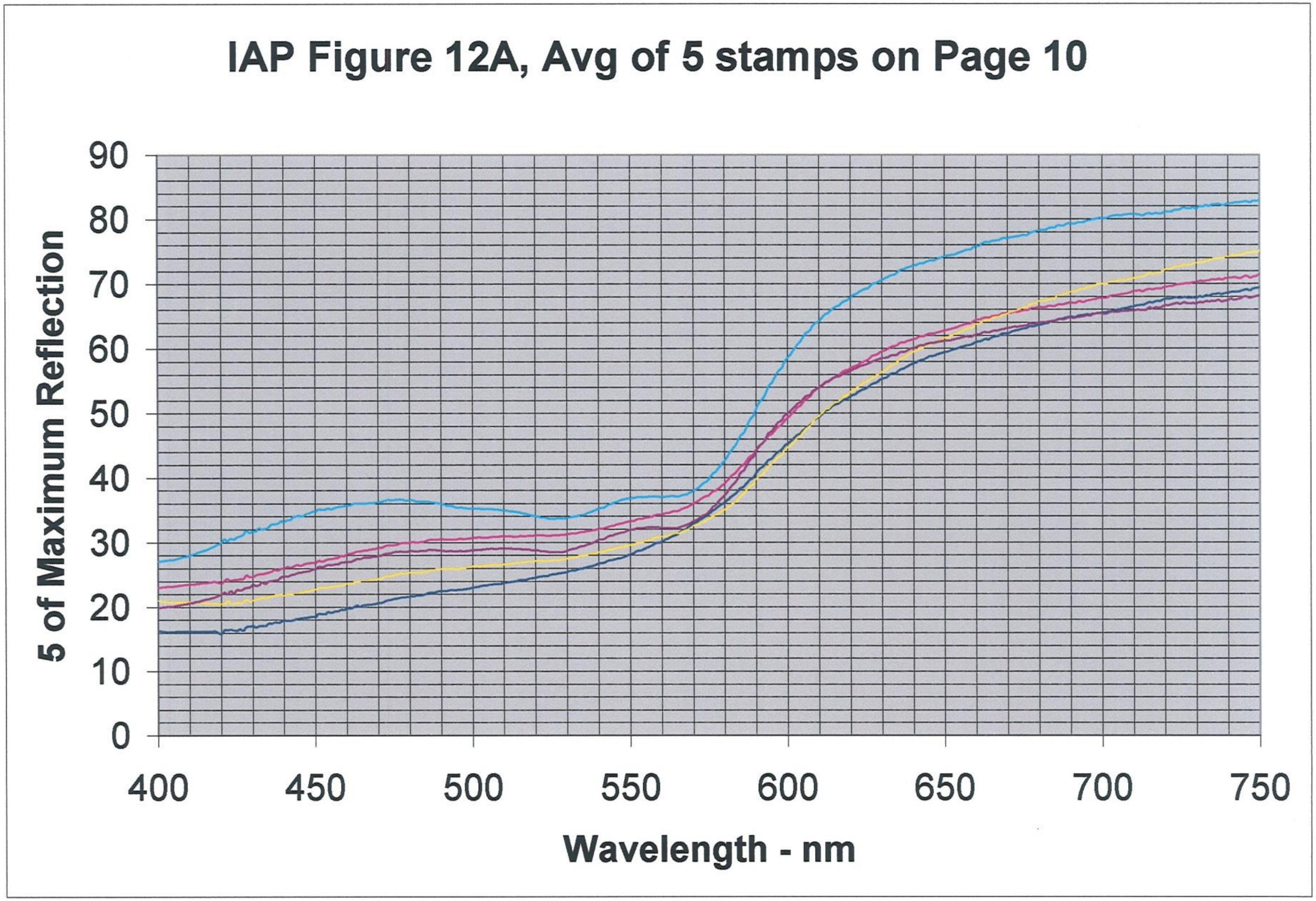


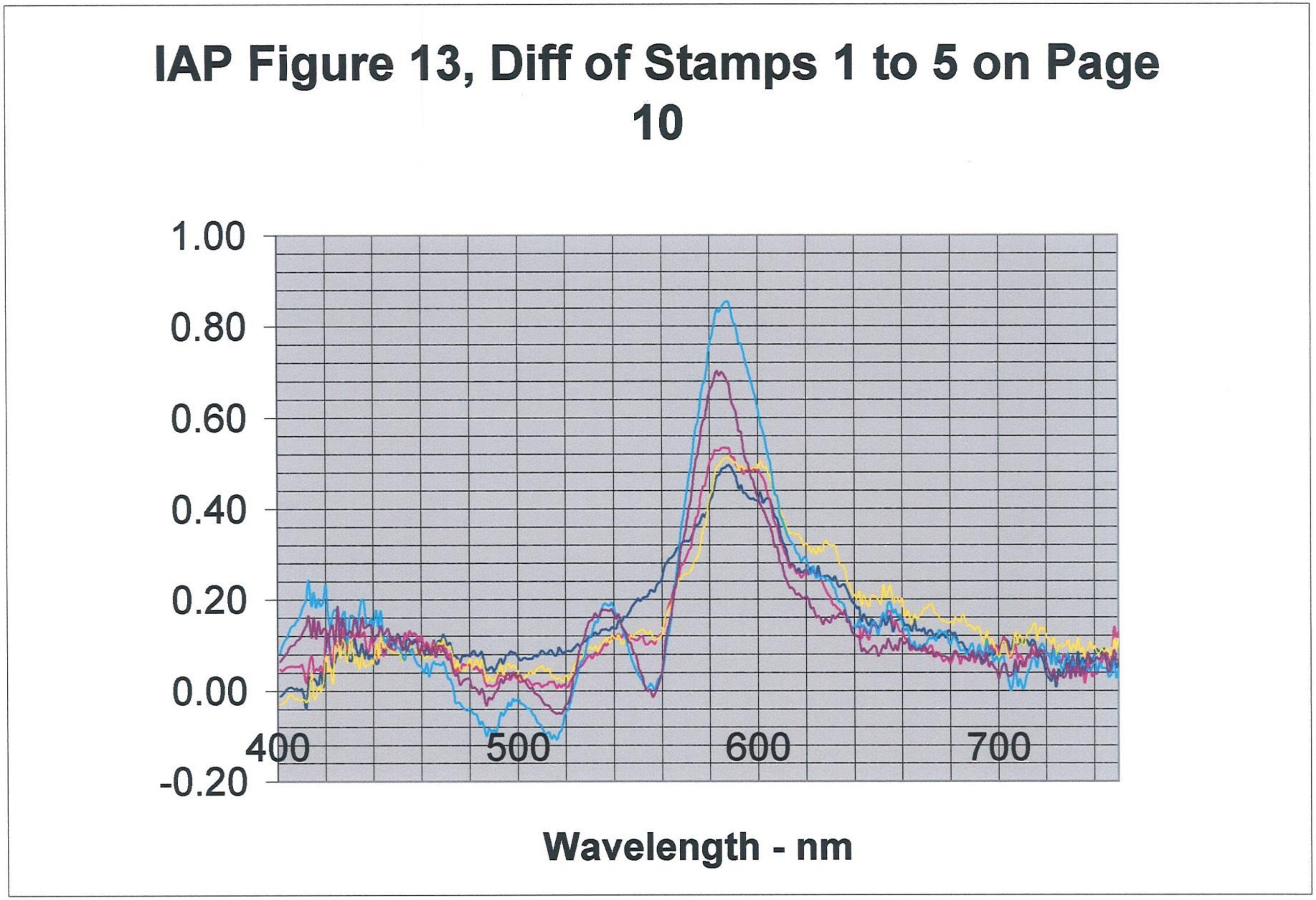
PIGEON BLOOD

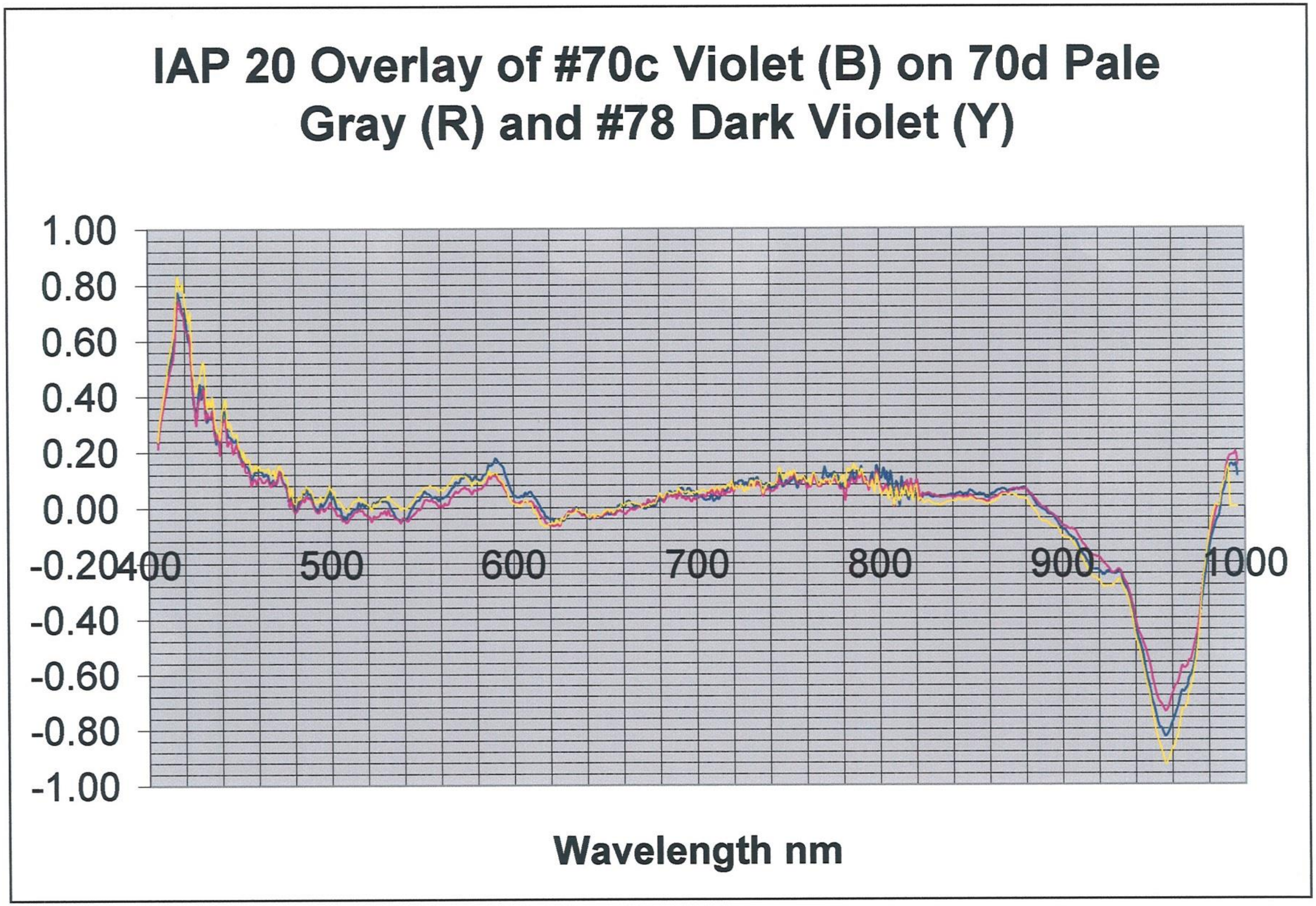
IAP Figure 10, over print of average of #41, #44 and #4, three "Pigeon Blood" stamps




IAP Figure 11 stamp #41, #44, and #4 Diff.
Three "Pigeon Blood" stamps
0.90
0.70
0.50
0.30
0.10
-0.10
-0.30
-0.50
400
450
500
550
600
650
700
750
Wavelength - nM


IAP Figure 12A, Avg of 5 stamps on Page 10
90
80
70
60
50
40
30
20
10
0
5 of Maximum Reflection
400
450
500
550
600
650
700
750
Wavelength - nm


IAP Figure 13, Diff of Stamps 1 to 5 on Page 10
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
400
500
600
700
Wavelength - nm


IAP 20 Overlay of #70c Violet (B) on 70d Pale Gray (R) and #78 Dark Violet (Y)
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
-0.40
-0.60
-0.80
-1.00
400
500
600
700
800
900
1000
Wavelength nm